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PROJECT ARTEMIS

High Power Acoustic Source -

EFFECT OF TRANSDUCER ELEMENT ELECTRICAL CONNECTION ON INTERACTION IN A CONSOLIDATED ARRAY (U)

(Unclassified Title)

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SOUND DIVISION

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ABSTRACT

This report describes tests that were made in air on an array of four type TR-11C transducer elements having their external masses clamped together. The purpose of the tests was to evaluate the effect of electrical interconnections on the displacement of the internal and external masses of an array of consolidated elements. The data revealed that the use of parallel connection of the transducer elements as opposed to series connection should result in a significant decrease in spring deflection. However, due to the limited scope and conditions of the tests, additional experimental investigation is required on a larger array in water where transducer interaction is present to ascertain the extent of the improvement to be obtained from parallel connection as opposed to series-parallel connection.

PROBLEM AUTHORIZATION

ONR RF 001-03-03
NRL Problem Number 55S02-11

PROBLEM STATUS

This is an interim report on one phase of the project; work is continuing.

INTRODUCTION

Electroacoustic tests performed on the transducer array installed on the USNS MISSION CAPISTRANO (T-AG 162) reported in U. S. Naval Research Laboratory Memorandum Reports 1205, 1214 and 1273 (Project ARTEMIS High Power Acoustic Source, Interim Reports 1, 2 and 3 on Acoustic Performance) have revealed interaction effects between transducer elements. It was observed throughout these experiments that the velocity anomalies across the face of the array were in part responsible for large spring deflections. Furthermore, the variation in transducer electrical impedance resulting from changes in acoustic loading across the array apparently accentuated the effects of element interaction. This, it is believed, resulted from the series-parallel electrical configuration used to interconnect the transducers.

The transducers were connected in parallel groups with each group consisting of six elements in series. Thus, the same current is imposed on six elements in the series string of six transducers. If one or more of these transducer elements in a particular series string of six exhibited a higher impedance due to the loading condition, it is forced to accept a larger share of the electrical power delivered to that series network of six transducer elements; that is, the proportion of power to this one transducer element would be in excess of that shared by each of the other elements within the group.

On the basis of these observations, it appeared that an improvement in performance of the array (that is, a reduction in the velocity anomalies) would result if all elements were connected in parallel electrically. Also, consideration was given to the possibility of reducing interaction effects by using transducer elements having larger radiating surfaces. This would be achieved by cementing or consolidating a group of elements together. The elements forming each consolidated group should have a nearly uniform velocity of the radiating surface. Obviously, consideration would then have to be given to the action of the internal mass of each element in this consolidated array. A simple experimental procedure for evaluating this was developed and the experimental work performed.

EXPERIMENTAL PROCEDURE

In order to keep the experimental procedure for initial evaluation simple, a test involving a few elements was desired. On the other hand, such an array would not necessarily load properly in water to permit adequate comparison of series versus parallel connection under this condition. It appeared, however, that a preliminary evaluation could be made of the consolidated group by clamping the external mass of four transducers together and driving this group in air. This would establish nearly equal movement of the radiating faces and permit evaluation of movement of the internal mass for series and parallel connection.

The Massa Division, Cohu Electronics, Incorporated, modified four standard TR-11C transducer elements by mounting accelerometers on the internal mass. These four elements were clamped together mechanically in a configuration as shown in figure 1. Accelerometers were mounted also on the center of the external radiating face of each transducer element.

These four elements were connected electrically in either series or parallel to the amplifier and measurements made of the deflection of the internal and external mass of each of the four elements over the frequency range from 260 to 500 cycles per second. Displacement data included amplitudes and phase information. The polarizing current to each transducer element was ten amperes dc. The ac current for the series connection was 0.04 amperes. When the elements were tested in parallel, the total current to the four transducer elements was held constant at 0.16 amperes. All tests were performed with the element in air suspended from a cable in order to minimize damping of the transducer elements by the support mechanism.

EXPERIMENTAL RESULTS

The experimental results obtained for the transducer elements connected in series electrically are presented in figures 2a through 2d and 3a through 3d. Inspection of the data in figure 2 reveals that the displacements of the outer masses of each of the four transducer elements were very nearly equal. On the other hand, large variations are to be noted on the relative displacements of the inner masses. It will also be observed that the ratio of inner mass displacement to outer mass displacement has a maximum value in excess of twelve to one. Figure 3 shows the variations and differences between the phase of the internal and external mass displacement.

The experimental results obtained with the transducer elements connected electrically in parallel are shown in figures 4a through 4d and 5a through 5d. Again it will be noted that the displacements of the outer masses are all nearly equal. However, it will be noted that motion of the inner mass has been greatly reduced over that noted for the series connection. Also, the ratio of inner mass displacement to outer mass displacement has a maximum value less than four to one. This represents a major reduction in spring deflection for a given displacement of the outer mass. Comparison of spring deflection for the parallel connection with the series connection reveals a ratio as high as 1 to 3.7.

The phase variation of the four transducer elements, which is shown in figure 5, has also been noticeably changed over the characteristic displayed when the elements were connected in series. Of particular interest is the large irregular behavior which is to be observed on all four elements at 380 to 390 cycles per second. A cursory investigation was made to ascertain the cause of this large deviation of the phase and amplitude curves in this frequency region. This examination consisted of observing the displacement of the top and bottom of the internal mass by means of two accelerometers mounted in these corresponding positions. The results of this experiment indicated that the inner mass had an additional mode of vibration. This may be a flexural mode or it may be that the inner mass has a rotational component superimposed on the lineal component. This requires further investigation.

It was stated in the experimental procedure that the current to the four transducer elements when series connected was maintained at 0.04 amperes. When the transducer elements were connected in parallel, the total current was maintained at 0.16 amperes. The current to each of the transducer elements when parallel connected was monitored and the results plotted in figure 6. It will be observed that the current to each of the elements differed at certain frequencies. However, the variation in this magnitude does not appear to be adequate to account for the observed change in displacement of the inner mass. The relative phase of the current may explain this but unfortunately phase data was not obtained.

CONCLUSIONS

These tests made on four transducer elements clamped together in air revealed that a marked improvement can be made in the ratio of displacement of the inner mass to the external mass by changing the electrical connection from a series configuration to a parallel configuration. These results, because of their limited extent, must be considered preliminary only. However, they do reveal that further experimental work is in order to evaluate the effect of parallel connection versus series-parallel of consolidated arrays in water. This program should also evaluate the effects of electrical connection on interaction of an array of unconsolidated elements.

ACKNOWLEDGEMENT

The modified transducers, the experimental set-up and acquisition of data were provided by the Massa Division, Cohu Electronics, Incorporated, in cooperation with personnel of the U. S. Naval Research Laboratory. These data were obtained during November 1961.

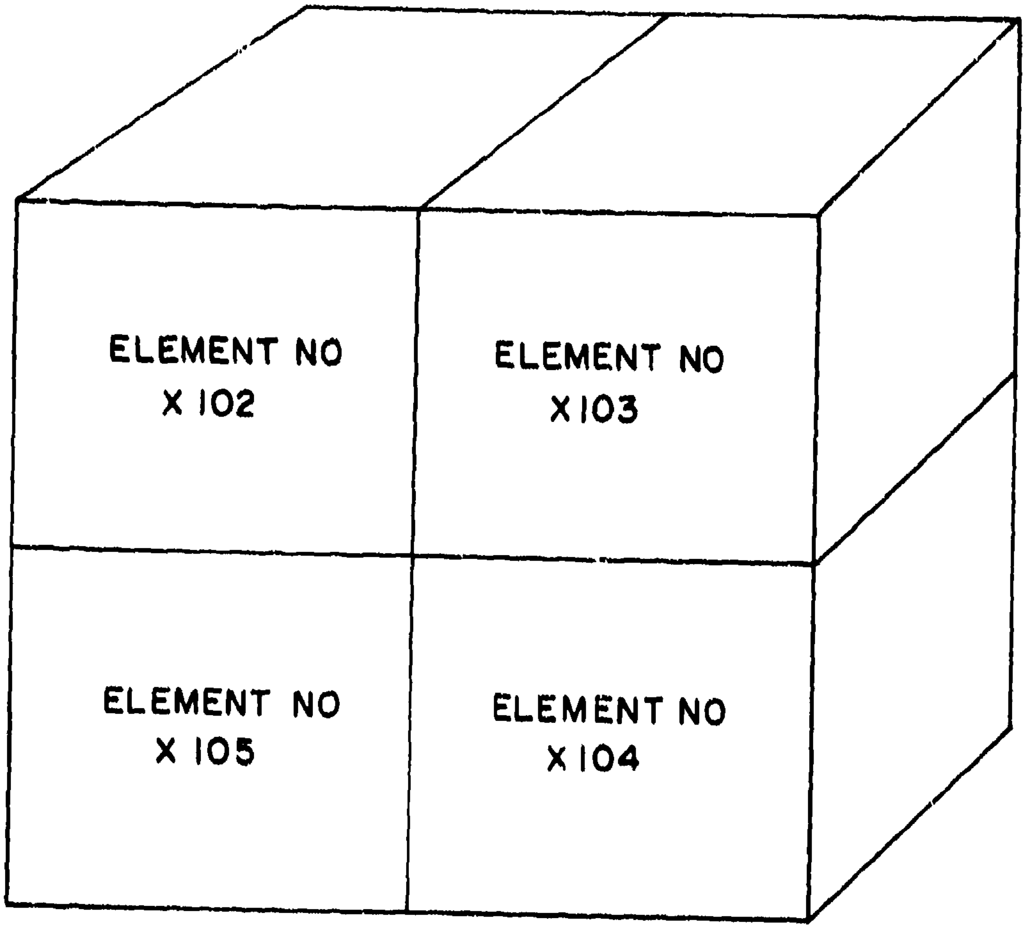

Fig. 1 - Type TR-11C element position as clamped in the array

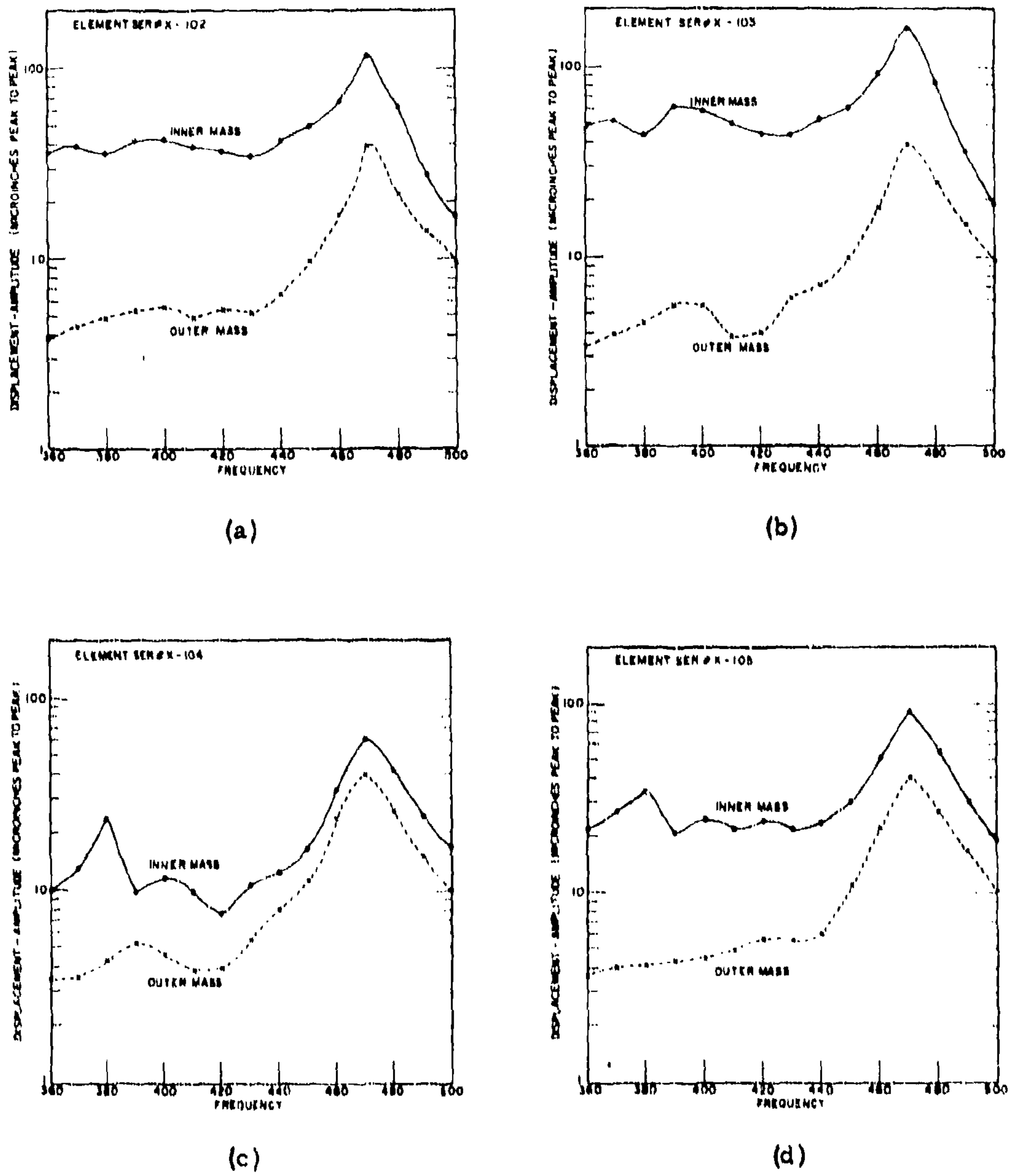

Fig. 2 - Displacement amplitude for series connection

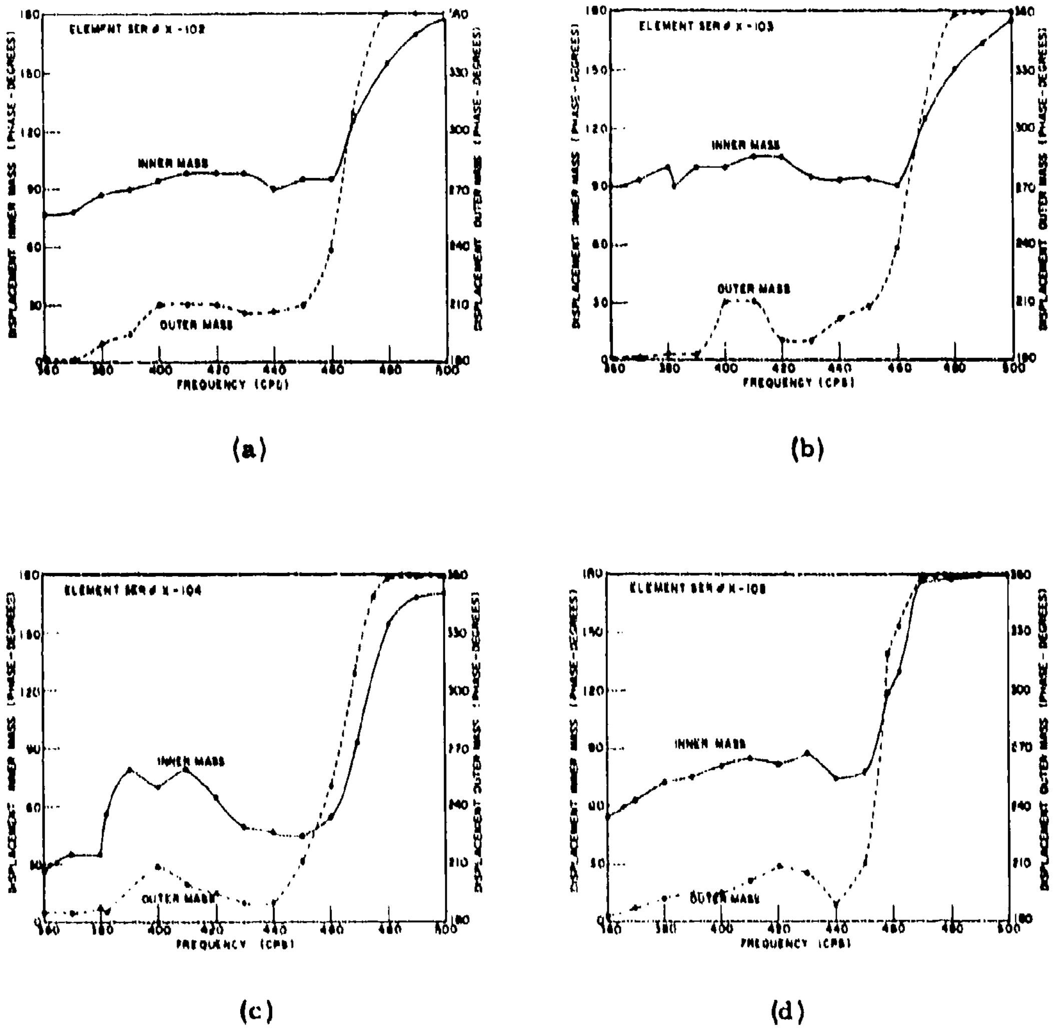

Fig. 3 - Displacement phase for series connection

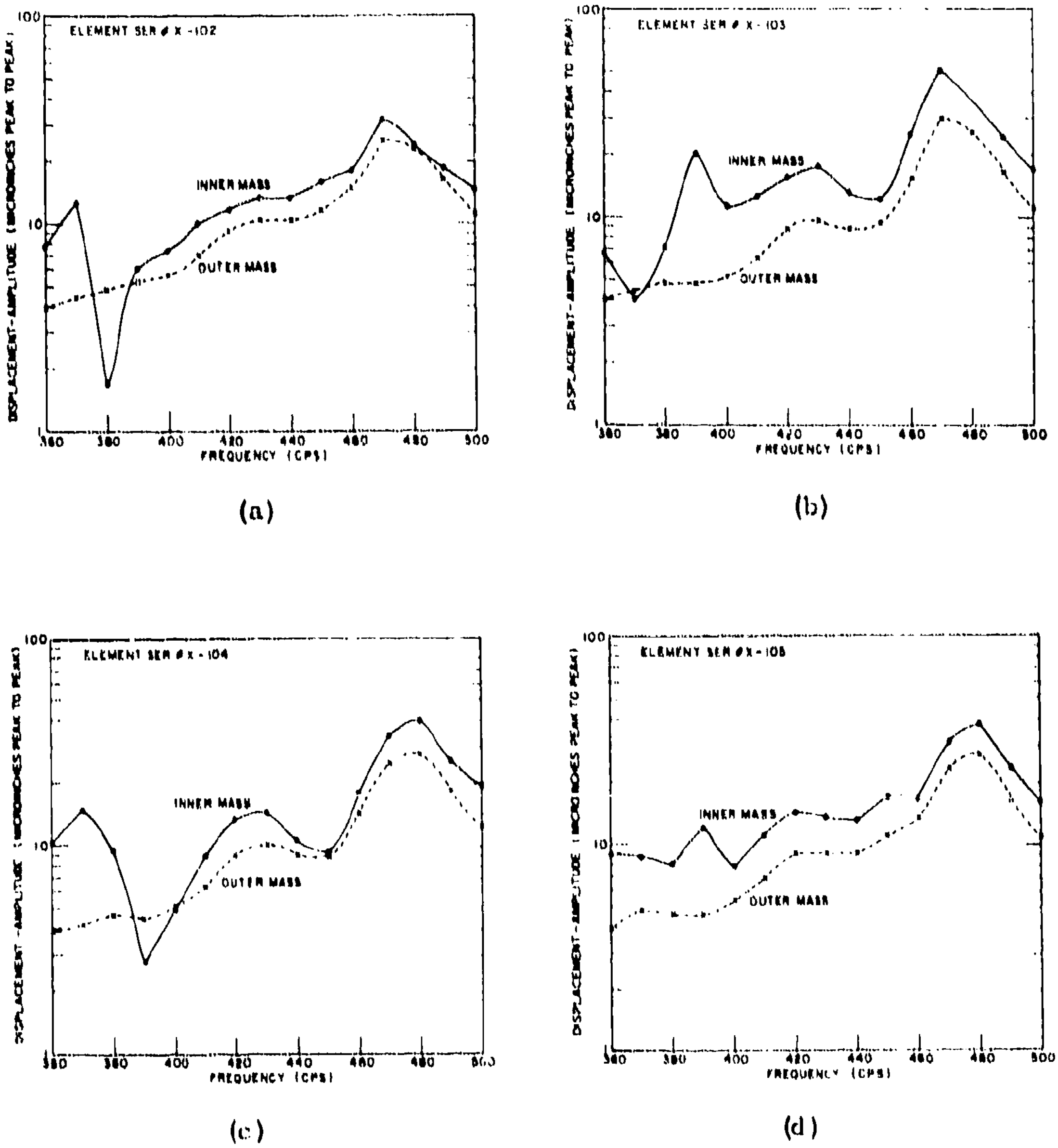

Fig. 4 - Displacement amplitude for parallel connection

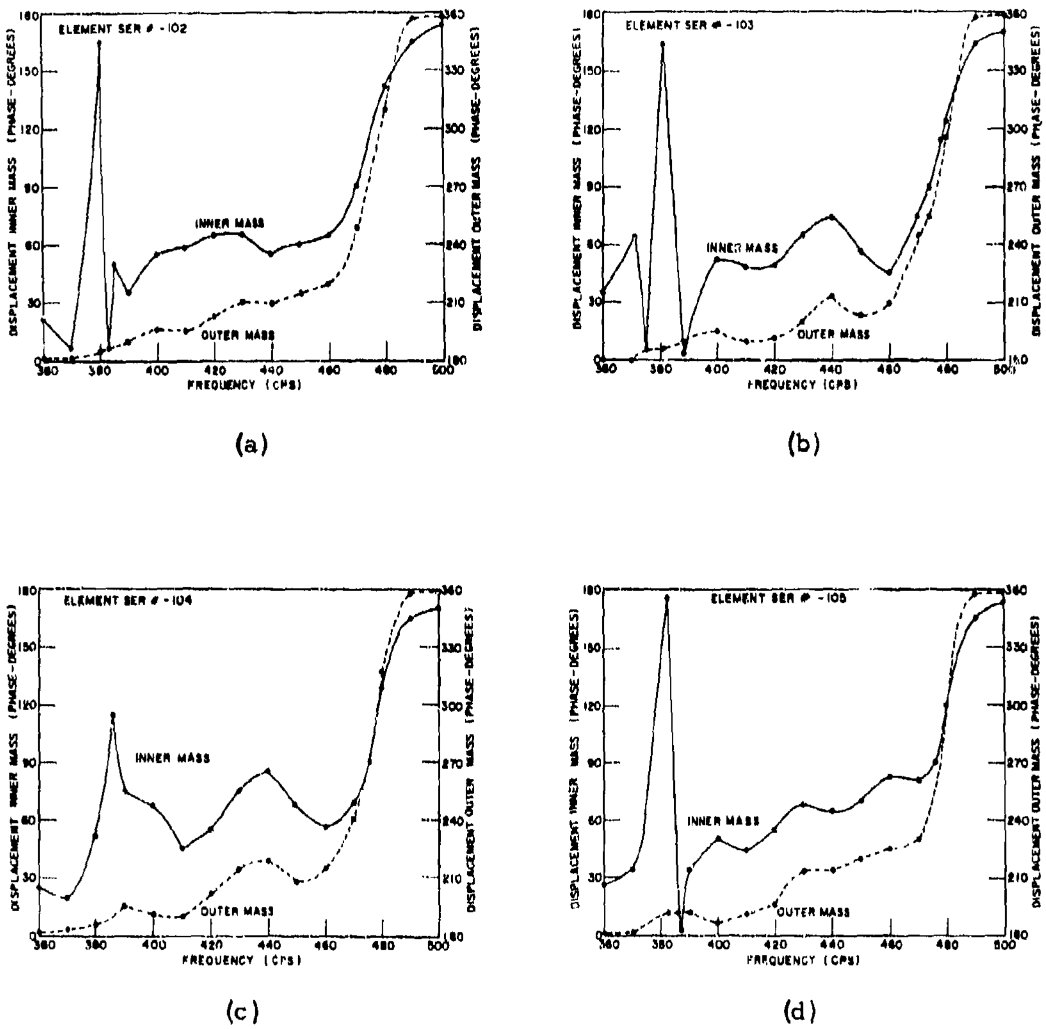

Fig. 5 - Displacement phase for parallel connection

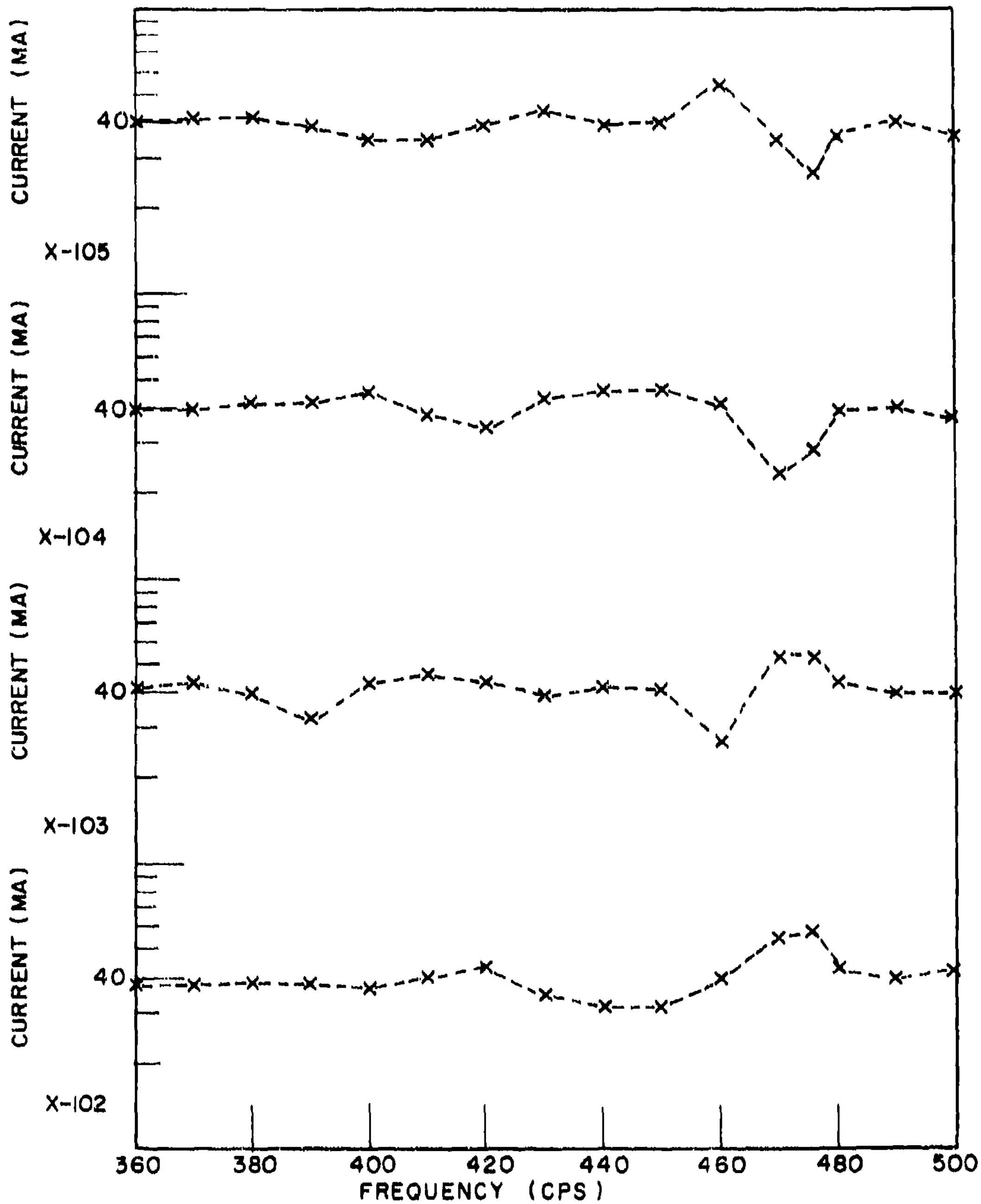

Fig. 6 - Transducer current for parallel connection

UNITED STATES GOVERNMENT

Memorandum

7100-016

DATE: 22 January 2004

REPLY TO ATTN OF: Burton G. Hurdle (Code 7103)

SUBJECT: REVIEW OF REF (A) FOR DECLASSIFICATION

TO: Code 1221.1

REF: (a) "Project ARTEMIS High Power Acoustic Source", A.T. McClinton, R.H. Ferris, W.A. Herrington, Sound Div., NRL Memo Report 1205, 3 Aug 1961 (U)
(b) "Project ARTEMIS High Power Acoustic Source Second Interim Report on Acoustic Performance", A.T. McClinton and R.H. Ferris, Sound Division, NRL Memo Report 1214, 19 September 1961 (U)
(c) "Project ARTEMIS High Power Acoustic Source Third Interim Report on Acoustic Performance", A.T. McClinton, R.H. Ferris, Sound Division, NRL Memo Report 1273, 23 April 1962 (U)
(d) "Project ARETMIS High Power Acoustic Source Effect of Transducer Element Electrical Connection on Interaction in a Consolidated Array", A.T. McClinton, Sound Division, NRL Memo Report 1323, 4 June 1962 (U)
(e) "Test of Project ARTEMIS Source", R.H. Ferris, Sound Division, NRL Memo Report 1648, 15 September 1965 (U)
(f) "Power Limitations and Fidelity of Acoustic Sources", R.H. Ferris and F.L. Hunsicker, Sound Division, NRL Memo Report 1730, November 1966 (U)
(g) "Project ARTEMIS Acoustic Source Acoustic Test Procedure", R.H. Ferris and C.R. Rollins, Sound Division, NRL Memo Report 1769, 5 June 1967 (U)
(h) "Calibration of the ARTEIS Source and Receiving Array on the Mission Capistrano", M. Flato, Acoustics Div., NRL Memo Report 2712, Dec 1973 (U)
(i) "Theoretical Interaction Computations for Transducer Arrays, Including the Effects of Several Different Types of Electrical Terminal Connections", R.V. Baier, Sound Division, NRL Report 6314, 7 October 1965 (U)
(j) "Project ARTEMIS Acoustic Source Summary Report", NRL Report 6535, September 1967 (U)

1. References (a) thru (j) are a series of reports on Project ARTEMIS Reports by the Sound Division that have previously been declassified.

2. The technology and equipment of reference (a) have long been superseded. The current value of these papers is historical

3. Based on the above, it is recommended that reference (a) be available with no restrictions.

Burton G. Hurdle
BURTON G. HURDLE
NRL Code 7103

CONCUR:

Edward R. Franchi 1/23/2004
E.R. Franchi Date
Superintendent, Acoustics Division

CONCUR:

Tina Smallwood 1/28/04
Tina Smallwood Date
NRL Code 1221.1